DOCUMENT RESUME

ED 352 002 IR 015 830

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TITLE Mathematics Instruction through the Open University.
PUB DATE 91
NOTE 14p.
PUB TYPE Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *College Mathematics; Developing Nations; *Distance Education; Educational Technology; Foreign Countries; Higher Education; *Mathematics Instruction; Multimedia Instruction; Nontraditional Education; *Open Universities; Services; Teaching Methods
IDENTIFIERS *Open University of Sri Lanka

ABSTRACT

After a brief review of the literature and definition of educational technology, this paper describes the process of mathematics instruction at the Open University of Sri Lanka (OUSL). It is noted that the unique situation at OUSL and the abstract nature of mathematics make it necessary to modify the system of distance education because it is difficult to apply modern distance education technologies without incurring unrealistically heavy expenditures, and that a maximum number of face-to-face sessions is an essential component in the OUSL distance education scheme. Topics highlighted in this paper include: (1) the subject area of mathematics as one of the oldest sciences and its impact on education; (2) the mathematics curriculum at OUSL, including the basics of math, meeting the needs of those who use math, and teaching mathematical logic; (3) the student-centered individualized learning system used at OUSL to teach math; and (4) the current need for occasional face-to-face sessions as an essential component in distance education mathematics instruction at OUSL. It is suggested that, as multimedia technologies are improved, fewer face-to-face sessions may be needed. (ALF)

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MATHEMATICS INSTRUCTION THROUGH THE OPEN UNIVERSITY

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1 Introduction.

"How marvellous if all knowledge came into our minds simply as a result of living, without any need for more effort than is required to eat or breathe ! "

- Maria Montessori -

"A book is a machine to think with." - I. A. Richards -

The two quotations express the hope and the despair of the educationist. As Maria Montessori laments, learning does not take place "simply as a result of living, without any need for more effort than is required to eat or breathe", except during early childhood when the capacity to learn (the mother tongue) appears to be a biological endowment. At some stage or another, the learner has to be taught, or in the words of Montessori herself, has to be subjected to "special scholastic influences", such as the memorizing of the multiplication

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table in arithmetic. Book learning, on the other hand, appears to be deceptively simple. In fact, as I. A. Richards points out, "a book is a machine to think with". This is plain to the learner who encounters a concisely written book in mathematics such as one on the theory of functions or the symbolic logic. What is not often realised, however, is that even the best piece of self-instructional package in mathematics more or less, "is a machine to think with" .

Educational technology (ET) tries to close the gap between expectation and reality by simplifying for the learner the process of absorption of knowledge.

Definition : ET is a systematic way of designing, implementing and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication and employing a combination of human and non-human resources to bring about more effective instruction.

- Commission on Instructional Technology, USA -

Thus the declared aim of ET is "to bring about more effective instruction", and for this purpose it considers "the total process of learning and teaching". "More effective instruction" may be taken to mean :

(a) increasing the quality of learning or the degree of mastery ;
(b) decreasing the time taken for learners to attain desired objectives or goals ;

and other factors such as increasing the number of learners taught and reducing costs without affecting quality, etc.

We shall, in the sequel, adopt the above description of ET as a working definition and discuss the process of mathematics instruction through the Open University : its curriculum, methodology, and its gradual evolution into a stable but dynamic system.

1.1 Mathematics, the subject.

Mathematics is one of the oldest of the sciences. In our own day it forms an edifice of colossal proportions whose methodologies play a key role in the development of the experimental sciences. The widespread use of mathematics in these sciences and elsewhere in education is basically due to the fact that it can be used to answer

the key question : Is such and such a claim coherent and logical ? Mathematics, by its very nature, is designed to answer such questions. The distinguishing feature of mathematics is that it forces scientists to make their concepts more precise and later reveal more easily the logical implications of these concepts.

The impact of mathematics on education is phenomenal and there always seems to be an urgency of learning and using mathematical tools. This fact has to be kept in mind when formulating a technology of mathematical education. The growing numbers of learners, the widening desire for higher education, and the shift from arts to sciences, all this creates a kind of turmoil in which mathematics figures very prominently. As the influence of analytical sciences outgrows that of the humanities, so mathematics, the one discipline common to all the sciences, will have ever greater influence thrust upon it. By the universality of its applications, mathematics has created for itself such an indispensable position in the fabric of education that it will survive, as it did in the past, on its own merit. However, it is important to be able to apply refined educational practices in order to communicate this important tool to future generations with ease and accuracy.

For centuries, through the Greeks, Copernicus, Galileo and Newton, and right up to modern times education in mathematics con-

sisted of face-to-face instruction and self-instruction through textbooks such as Euclid's Elements. Judging from historical evidence there is no doubt that face-to-face teaching is decisively the more important factor in the transmission of mathematical knowledge through the ages, although in the case of pioneers of science, self-instruction and research would have played important roles. Can we now afford not to teach mathematics face-to-face, at least in the case of distance education ? Perhaps we can. However, if we adopt the definition of ET given in section 1 as applying to distance eduction as well, the answer would be different. Although we can teach mathematics without any face-to-face contact, we can do much better if we include this historic component in our methodologies.

2 The curriculum.

The basics of mathematics are now not the same as they were, say, half a century ago although syllabuses have not always changed accordingly. What then are the basics of mathematics which at the present time form the core of a gateway to mathematics ? In answer to this question we quote below a portion of an article by W. Servais originally published in Mathematics Today, entitled : "A Modern Secondary School Syllabus in Mathematics for the Scientific Stream" (1964). See [{2}, p 217].

"(01) There are three areas which are of vital importance for the application of mathematics to physics, biology and human sciences : vector spaces; elements of analysis ; elements of probability and statistics.

These are the lines on which teaching must be organized if it is to meet the needs of those who use mathematics. Moreover, these themes provide the substance for a complete mathematical education.

(02) Mathematical logic is acquiring greater importance every day. It is recommended that a study should be made of it as soon as possible in conjunction with that of sets using one to throw light on the other. In this way the notions and criteria essential for formulating statements and definitions, and for developing mathematical demonstrations will become familiar".

Servais goes into immaculate detail in order to justify the choice of the quintuple : set theory, logic, vector spaces, elements of analysis, probability and statistics. One cannot help noticing the insistence with which concepts from these branches keep surfacing everywhere in mathematics and its applications. In particular, a course on set theory and logic seems to satisfy almost all of the intellectual needs which for centuries were satisfied by classical euclidean

geometry.

In developing countries, the task of teaching this "pancha ganita" cannot be left to the schools alone. Much of it will spill into the early years of a university education. This will be more so of the open universities in the third world such as the Open University of Sri Lanka (OUSL). In fact, in the Division of Mathematics of the OUSL, elements of pancha ganita occupy most of the preliminary levels of study. This is the area, if any, for which more face-to-face teaching can be recommended. In fact, this quintuple is so basic that even a policy of spoonfeeding and indoctrination seems to be justified from an educational point of view. After all, were learners not spoonfed with Euclid in a bygone era even in the West ? Why should we now not take some extra steps to educate the open university undergraduate with these core courses in mathematics ? Perhaps, high quality distance teaching materials with a liberal touch of face-to-face instructions could go a long way in achieving the desired objectives in these basic areas of mathematics.

At present the Division of Mathematics of the OUSL offers courses in pure and applied mathematics for candidates reading for the B.Sc.(General) degree. There are five levels of study, the first two being foundation levels of a remedial nature, roughly equivalent to the G.C.E.(Advanced Level). At the next three levels students fol-

low more advanced courses comprising of, among others, units in linear algebra, real analysis, probability and statistics, number theory, complex analysis, newtonian mechanics, analytical dynamaics, relativity and quantum mechanics. A course entitled Mathematical Modelling is offered which introduces the student to an independent study leading to a project report. Also a new course in automata theory was added to the curriculum in 1991. These courses, administered through the distance mode, are a challenge to a relatively new open university such as the OUSL.

3 Methodologies.

The open university, overwhelmingly, is a student-centred individualized learning system. It embodies within itself safeguards which prevent it from deteriorating into a poor imitation of a conventional university. At the OUSL, face-to-face instruction in mathematics is carried out by a system of Day Schools. These are usually held on public holidays so that employed students can also attend them. The number of day schools for a $\frac{1}{6}$ credit course is usually two and attendance is not compulsory. However, we find that attendance at these face-to-face sessions is usually over 80 or 90 per cent and popular student requests for one or two extra day schools are not uncommon.

One of the two day schools allocated for each course is invariably spent in giving an overview of the whole course while the other is used to explain difficult or obscure points. An extra day school or two may be held for a course which the students find difficult or when the solutions to assignment questions need to be discussed. Usually, a day school is a happy occasion where the students are able to meet their colleagues and discuss things of mutual interest. The procedures at day schools are not rigidly laid down and the discussion may take the form of a teacher-controlled group learning session.

The OUSL student of mathematics is assessed both continuously during the course and in the final examination. The continuous assessment component for a $\frac{1}{6}$ credit course consists of two assignments which are set meaningfully to cover the more important course objectives. The importance of devoting a maximum of effort and time in attempting these assignments is constantly emphasized and very often books are prescribed which the learner may consult with profit. In the case of exceptionally difficult or elusive problems hints may be provided, at the discretion of the instructor, at a day school during a face-to-face session. Finally, after the assignment answer scripts have been marked and graded, a model answer is always provided, in keeping with sound educational principles. This is sometimes fol-

lowed by a day school where solutions to problems are discussed in a group atmosphere and alternative methods, if any, are evaluated comparatively.

The overview aspect of a course is extremely important since it reminds the student that mathematics is not all problem solving. In fact, an overview of a course is provided for, for example, in the Keller Plan, which is an extremely sophisticated system of individualized learning found to be specifically suitable for teaching science subjects at the university level. See Percival and Ellington [{1}, p 42]. We have found that the evolving system of mathematics instruction at the OUSL with its self-contained textual software and the complement of day schools, is remarkably similar to that of the Keller Plan, except for the fact that self-pacing in the long term is not provided for in view of the institutionalized nature of instruction and certification. Some courses have study guides and, usually, tutorial assistance of a most open variety is freely available. What may be lacking or needs to be cultivated is a high level of student motivation.

Distance education institutions in Sri Lanka, like its political institutions, have benefited immensely from its parent institution in the United Kingdom. In fact, the Open University of the United Kingdom (OU,UK) assisted the OUSL in setting up its first mathe-

matics courses by lending us some adapted versions of the OU,UK material. It is interesting to compare the development of the OU,UK with the latter day development of the OUSL. Percival and Ellington [{1}, *p* 26] states:

"This institution (OU,UK) originally conceived during the early 1960s as the 'University of the Air', started offering courses in 1971 using the media of television and radio broadcasts, and there was an extensive period of software development (mainly textual) in order to support students studying on an individualized basis. More recently, there has been a much greater concern with providing situations for closer contact with other students and with tutors, and there has been a more human, or group, approach to learning, although such developments have been somewhat restricted owing to financial considerations."

These more humanistic developments in education which Percival and Ellington perceive in the OU,UK are paralleled in the OUSL by the less expensive and more familiar Day School concept. The flexible day school system obtaining in the OUSL methodology from its inception, evolved through a decade, is now a powerful medium of essential instruction. Judging from its popularity one cannot help feeling that these face-to-face sessions in fact satisfy some deep-seated need of the learner's psyche.

4 Conclusions.

Distance education, by its very definition, should ideally have none or only a minimal amount of face-to-face instruction since learning presumably takes place away from the host institution. This conception covers extreme cases where, for example, the distance learner may be on the other side of the globe from his/her institution. However, the situation in the OUSL and other similar institutions is conditioned by a combination of indigenous factors such as geographic, cultural, social and economic conditions which tend to play an important role in modifying the system of education as a whole. This is specially evident in subjects such as mathematics where the abstractness of subject matter sometimes makes it very difficult to apply modern distance education technologies without incurring unrealistically heavy expenditure. The OUSL experience in mathematics instruction has been that the occasional face-to-face session is an essential component in its distance education scheme. In fact, there has been a strong case for holding a maximal amount of face-to-face instruction, within the framework of distance educational technology, at least in the case of core courses in mathematics. However, even this maximum is only a tiny fraction of what is offered by a conventional university. It is hoped that, as the multimedia machinery is improved and gradually perfected, so, the day

school component will gradually dwindle in size, though perhaps not in its enormous significance.

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